I. C. 7429

FEB 27 1948
O. S. U. LIBRARY

FEBRUARY 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
JAMES BOYD, DIRECTOR

INFORMATION CIRCULAR

DIAMOND-DRILLING BLAST HOLES, BELL MINE THE WARNER CO., CENTRE COUNTY, PA.

BY

MCHENRY MOSIER

I. C. 7429,
February 1948.

INFORMATION CIRCULAR

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

DIAMOND-DRILLING BLAST HOLES, BELL MINE, THE WARNER CO., CENTRE COUNTY, PA.[1]

By McHenry Mosier[2]

SUMMARY

The Bell mine operated by the Warner Co. at Bellefonte, Pa., has an annual production of about 600,000 short tons of high-grade limestone. Since 1924, shrinkage stoping has been the mining method. Horizontal, long-hole diamond-drilling for production in stopes was started with one machine in July 1946. It is now standard practice. The burden on the holes is 10 feet. Diamond bits are noncoring EX-size in both concave and pilot types. The two types have little difference in drilling speed at the Bell mine. The diamond drills are mounted on 3-inch single-screw columns.

Diamond drilling shows a marked increase in efficiency at the Bell mine, compared to percussion drilling, with respect to tons broken per drill shift, tons broken per foot of hole, and tons broken per pound of explosive. The advantages of diamond-drilling blast holes also include (a) improved safety, greater footage per drill shift, (c) better fragmentation of the broken stone, and (d) reduction in amount of barring down required in stopes because the working places are limited to slots which have a relatively small area.

INTRODUCTION

This paper is one of a series undertaken by the Mining Branch of the Bureau of Mines, Lowell B. Moon, chief, to describe current practice in diamond drilling for production purposes at various mines throughout the United States and to discuss the relative merits of this method as compared with drilling by percussion rock drills.

The Bureau of Mines and the mining companies that cooperate in this investigation have the common objective of developing information on this type of drilling and making it available to all who may be interested in the possible improvement of mining operations.

---

[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7429."

[2] Chief, College Park Division, Mining Branch, Bureau of Mines, College Park, Md.

Original from THE OHIO STATE UNIVERSITY

The operating data in this paper were furnished to the author by Fred Warner, general superintendent, The Warner Co., Bellefonte, Pa., in April 1947.

GEOLOGY AND MINERAL DRESSING

Beds of steeply dipping, high-grade limestone about 50 feet thick have a length along the strike of several miles.

The crude stone at the Bell mine has a minimum content of $CaCO_3$ of 97 percent. It is calcined to quick lime or burned lime for the chemical industry, metallurgical flux, building, and agricultural purposes. Other products are ground and pulverized stone for glass manufacture and other industrial uses, for dusting coal mines, and for agricultural use.

The limestone in place weighs 160 pounds per cubic foot, which corresponds to a weight-factor of 12.5 cubic feet per ton. Mine-run, broken stone weighs about 100 pounds per cubic foot. The carbon dioxide loss in sintering is 44 percent by weight of the crude stone.

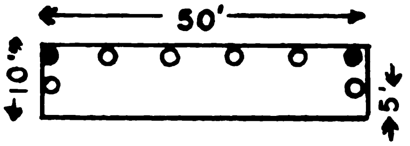
MINING METHOD

Underground mining at the Bell mine by the room-and-pillar method was started in 1922. The height of the rooms was 25 feet. In 1924, for safety considerations, the method was changed to shrinkage stoping. Shafts connect with a haulage level at a depth of 600 feet, where drifts have a cross section of 12 by 14 feet. Stopes 300 feet long and 50 feet wide are separated by 50-foot pillars. On a sublevel 35 feet above the haulage level, grizzlies with bars spaced 11 inches apart are installed in the stoping areas, at 60-foot intervals, over chutes to the haulage level. Fingers from the sublevel are raised 22 feet and belled to connect with the sill of the shrinkage stope. This sill is cut to a height of 10 feet.

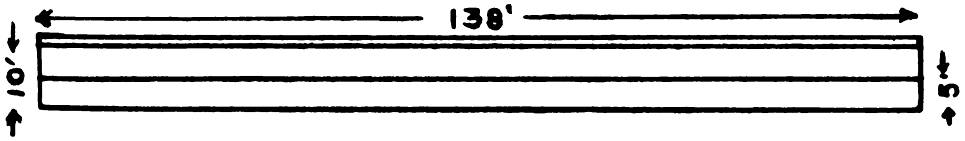
Manway raises are run in the pillars with entrance drifts into the adjoining stopes at vertical intervals ranging from 28 to 33 feet. The slot is cut by a percussion drill or by a diamond drill across the entire width of each stope along each pillar line, one round in advance of stoping. The use of a slot at each end of the stope, rather than a single slot across the center of the stope, reduces by one half the length of the horizontal blast holes, obviates shooting against the solid, and permits more diamond drills to operate. The diamond-drill blast holes average 138 feet in depth.

Six holes, with a burden of 10 feet, are drilled in a horizontal row across the stope on 10-foot intervals (See fig. 1.). In addition, two relievers with a 5-foot burden are drilled. One of these is on the footwall and the other on the hanging wall. The holes are loaded to the collar with 60-percent dynamite in 1-1/4- by 8-inch cartridges. All are fired with zero delay, No. 6 electric caps except the end holes in the horizontal row, which are detonated with No. 1 delays. The stoping lift is 200 feet, measured from the floor of the sill to the bottom of the floor pillars, which are 50 feet below the supply level.

Original from THE OHIO STATE UNIVERSITY



Cross section Through Slot



Longitudinal Section

Legend

0 Delay ○

1st Delay ●

Scale in feet

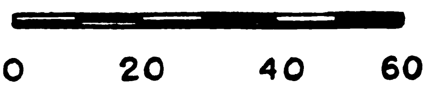


Figure 1. - Diamond-drill stope round.

The stone is hauled in 4-ton Granby-type cars on 80-pound rails. On the main line, an 8-ton trolley locomotive using 250 volts, d.c., pulls 22 cars per trip through a distance of 1.5 miles. For loading, the train is split into two sections of 11 cars. Each section is moved by 4-ton trolley locomotive. The limestone is hoisted in 6-ton skips.

DIAMOND DRILLING

The first diamond drill for blast holes started drilling July 1, 1946. In September 1946, four drills were operating and on February 1, 1947, six drills were in regular service, two shifts per day. In addition, an experimental drill used as a spare is on loan from the manufacturer. These drills are used for breaking ground in shrinkage stopes and for cutting slots across shrinkage stopes.

Diamond-drill operators are paid a straight daily wage. The crew comprises a driller and a helper for each machine.

Equipment

The six diamond drills have the following specifications:

Air motor	
Type	Rotary
Horsepower at 80 pounds air pressure	10
Feed	
Type	Screw
Run (length in inches)	27
Revolutions per inch of bit advance	100-1,200
Bit speed (range, r.p.m.)	0-3,300
Weight of drill (pounds)	155
Capacity (E rods - feet)	500

E rods in 5-foot sections are used exclusively. Rod pullers have not been found necessary in drilling the 138-foot, horizontal blast holes.

Bits are cast-set with best-grade stones in a sintered tungsten-matrix. They are noncoring, EX-size, in both concave and pilot types. The two types have little difference in drilling speed at the Bell mine. Although both types of bit give small deviation in drilling, the pilot bit causes less vibration and maintains slightly better alinement.

For loading long holes, a wooden tamping stick 1 inch in diameter in 5-foot sections joined with an interlocking, brass hook is proving safe and efficient.

Set-Up

Each diamond-drill machine is mounted on a 3-inch, single-screw column, either 5 feet or 6.5 feet in length. One machine operates in each transverse slot in each stope.

Air pressure is 110 to 120 pounds per square inch at the compressor and 90 pounds at the drill. Each machine uses about 15 gallons of water per minute at a pressure of approximately 100 pounds per square inch.

Results

Operating data for February and March 1947 follow. The basis of feet drilled per bit is the footage for all bits that have been run to destruction since July 1946. This record is being improved as each of the six bits now in service has drilled more than 3,000 feet, and one has drilled more than 8,000 feet.

In the tabulation, any fraction of a shift on drilling was counted as a full shift.

	February and March 1947	July 1946 to date
Feet drilled	24,525	
Feet drilled per bit:		
EX concave blast bit		2,141 1/
EX pilot bit		1,712 2/
Average		1,957
Diamond-drill shifts	265	
Feet drilled per diamond-drill shift	92.5	
Average depth of hole in stopes exclusive of cutting slots (feet)	138.0	
Short tons broken in stopes per foot of hole exclusive of cutting slots	4.6	
Short tons broken in stopes per diamond-drill shift, exclusive of cutting slots	420.0	
Short tons broken in cutting slots per diamond-drill shift	40.0	
Short tons broken in stopes per pound of dynamite, exclusive of cutting slots	8.0	

1/ 16 bits drilled 34,250 feet.
2/ 12 bits drilled 20,543 feet.

PERCUSSION DRILLING

Mounted 3.5-inch drifters were employed in cutting shrinkage sills and driving development drifts; stopes in manway raises and slot raises; and hand-held sinkers for block holing and utility work. Two men are used on a drifter. On the grizzly level (locally termed man-drift level), mucking is with a scraper pulled by a double-drum electric hoist. Blasting is with safety fuse and 60-percent semigelatin dynamite in 1.5- by 8-inch cartridges. A complete cycle of operations is made in one shift. In the shrinkage sill, holes are charged with 45-percent ammonia dynamite and fired by No. 6 electric blasting caps.

Detachable bits start with a 2-inch diameter and have a 1/16-inch-gage change. New bits are resharpened once. The deepest hole is 16 feet.

The results of percussion drilling in cutting slots and in opening sill floors during February and March 1947 are below.

Feet drilled in stopes by drifter drills	2,353
Drifter-drill shifts	41
Feet drilled per drill shift	57.5
Short tons broken per pound of explosives	4.5

Owing to the difference in the character of work now being performed in the Bell mine, a direct comparison of the results of percussion drilling with diamond drilling cannot be made on current operations. However, the following appraisal of the relative merits of the two methods was made by using approximate figures for percussion drilling that were obtained before diamond drilling was introduced.

MERITS OF DIAMOND-DRILLING BLAST HOLES AT THE BELL MINE COMPARED TO PERCUSSION DRILLING

The advantages of diamond-drilling blast holes in stopes are:

(1) Hazards in stopes are greatly reduced because work now is in narrow slots rather than under wide roof spans.

(2) More tons broken per foot of hole.

(3) Greater footage per drill shift.

(4) Powder consumption reduced by nearly 50 percent.

(5) Better fragmentation.

(6) Less barring down required because working places are limited to slots which have a relatively small area.

The disadvantages are:

(1) Machine upkeep is higher than for percussion drills.

(2) More difficult to charge and shoot long holes.

(3) Drilling cannot be completely standardized, because of the limited application of diamond drilling and the current necessity for using percussion drills in development headings and certain phases of stoping.

CONCLUSIONS

A notable development in diamond-drilling blast holes is the high efficiency of this work at the Bell mine as measured in tons broken per drill shift, tons broken per foot of hole, and tons broken per pound of explosive.